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## ABSTRACT

Historical data reveal that U.S. government policy and military and corporate interests have been instrumental in the development of nuclear energy and the underdevelopment of solar energy. It was not until 1972 that solar energy was funded by the Energy Research and Development Agency (ERDA) and in 1974 solar energy received \$12.2 million as compared to \$475.4 million for nuclear fission. Although a low-cost source of pollution-free energy, the photovoltaic solar cell, has been close to the point of availability for over twenty years, recommendations by scientists have not been followed by a sufficient commitment of funds to achieve any significant results. The lack of funding is a result of ERDA's commitment to the development of atomic energy. However, this commitment is a result of President Eisenhower's 1953 speech to the United Nations to lessen public anxiety about the dangers of atomic weapons. The speech created the Atoms for Peace Program in which the commitment of funds for nuclear power research was made not on the judgment of the potential of nuclear reactors as a source of inexpensive power, but rather as a legitimization for the continued development of atomic weapons. Therefore, the key difference between solar and nuclear research is that the commitment of government resources to the development of the atomic bomb led to the creation of a large-scale nuclear industry as part of the military-industrial complex. And, because large corporations in the oil-energy industry are committed by previous investments to oil, coal, and nuclear energy technologies, the potential source for the development of solar energy lies in the confluence of the environmental and anti-nuclear social movements. (Author/KC)

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THE POLITICS OF SCIENCE AND TECHNOLOGY:  
NUCLEAR AND SOLAR ALTERNATIVES

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### Abstract

A comparative case study in the politics of science and technology is presented utilizing historical data on the development of nuclear energy and the underdevelopment of solar energy. Differential funding of nuclear and solar R&D is related to United States government policy and military and corporate interests. The potential of photovoltaic solar cells, as detailed by researchers and government panels, is presented in the context of an analysis of the suppression of this technology. The possibility for mobilizing political support for the development of solar energy technology is suggested.

## THE POLITICS OF SCIENCE AND TECHNOLOGY

### Introduction

"In modern physics there are two fields from which we expect the greatest changes in the material conditions of life: the atomic nucleus and semi-conductors." (A. F. Yoffe)<sup>1</sup>

Atomic physics became the basis of a new energy industry during the post World War II era. From 1945-1975, in the United States, considerable resources were devoted to developing nuclear energy, a technology based on scientific discoveries about the atomic nucleus. During that same period few resources were devoted to developing photovoltaic solar cells, an energy technology based on scientific discoveries in the area of semi-conductors.

Why are the expectations for one scientific area realized and translated **into** significant technologies? Why is another related area left relatively undeveloped?

One theory of the development of science and technology holds that science is an institutional order apart from the rest of society. In this formulation science develops according to the intellectual interest of scientists and on the basis of the potential for significant theoretical results. (Ziman, 1968) (Merton, 1973)

Thomas Kuhn (1962), perhaps the most influential figure in the recent philosophy of science, provides another account of the development of science. He argues that major shifts in

research direction occur as a result of new problems that appear in the course of scientific research. Anomalies that existing theories can not satisfactorily explain lead to the development of new theories to account for them.

I will argue that the interplay between anomalies and theories is an internal process to a larger one in which the attention of large numbers of scientists are directed to one problem area rather than another. This external process is politically determined. Politicians, military and business leaders, the power elite (Mills, 1956), define an area of research as relevant to national political and economic goals and direct resources to support research in that area.

The ideology of the independence of science serves the interests of both the scientists and their financial supporters. The power elite achieves their political goals while the scientists maintain a state of false consciousness. They are enabled to pursue research that they might not undertake if they did not feel self directed. Government agencies and corporations thus determine the substance of science and gain the acquiescence of most scientists. Within this context scientists are free to select problems to research. Many scientists are unaware of the factors that influence their agenda selection process. Others argue that they are irrelevant. As long as the problems that are researched are theoretically significant the uses to which research is put is not their concern. A small but growing minority argue that research is politically directed toward

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military and corporate goals and should be redirected toward peaceful and humane ends.

At issue is the relationship of political institutions and political ideologies to the development of science and technology. Because scientific research is primarily funded by government and business, a decision to fund one area will inevitably focus the attention of scientists to that area. The commitment of resources to one area is the basis for the non-commitment of resources to another related area. Lack of funding can prevent scientists from pursuing research in the related area. The politics of the funding of scientific research is, therefore, the external process that shapes the intellectual interests of scientists.

Big science and little science do not develop independently on parallel tracks. The funding devoted to research directs the track that science will follow. The development of one area as big science is the cause of another related area left underdeveloped as little science.

The development of atomic energy as big science has kept solar energy underdeveloped as little science. The political exigencies of the Cold War required American policy makers to legitimate atomic research by emphasizing the peaceful potential of the atom. For "the peaceful atom" deflected growing public sentiment for the banning of atomic weapons. The argument could then be made that nuclear research had civilian as well as military applications. In fact the two are inseparable.

The funding of research on the peaceful uses of atomic energy was supported by claims that abundant and inexpensive electricity would be forthcoming from this research. This definition of the situation precluded serious consideration of funding alternative means to reach this goal.

In this paper I will compare the development of atomic and solar energy technologies to further our understanding of the forces involved in forming the direction of science and technology. The choice between nuclear and solar energy provides us with a source of data to examine this issue.

### I. The Solar Eclipse

For a brief period in the early 1950's solar energy appeared to be achieving viability as a useful technology, at least in the underdeveloped world. The government of India invited solar researchers from the United States and other developed countries to show them India's parched deserts and abundant sunlight and asked, "What can we do?" India established research institutes to develop practical solar devices for Indian villagers. But solar cookers and other solar instruments became mere exhibits rather than useful techniques. The cost of manufacture placed them beyond the reach of the villagers. (Behrman, 1976) Nor was the effort and resources put into solar research and development sustained and expanded. Within a few years the focus of India's research and development effort had turned to atomic energy. Under the impetus of an American plan to make cheap electrical energy, nuclear reactors became available to the underdeveloped world.

A few years later, "Solar energy was an intellectual backwater, almost a forgotten subject. Most of its leading practitioners had busied themselves with other things after the solar bubble of the 1950's had burst."<sup>2</sup> According to one solar proponent, Peter Glaser, "...in 1965 solar energy was as dead as a doornail."<sup>3</sup> Lack of significant funding, the absence of research centers, and the availability of inexpensive oil and natural gas have all been offered as reasons for the failure of solar energy to become a viable technology in the post World War II period. While these were contributing factors, official government sources were aware of the limited future availability of cheap gas and oil and of the need to develop alternative sources of energy. Scarcity of research funds and research centers are effects rather than causes of the failure to focus on solar energy. According to one observer:

The availability of cheap oil and natural gas and the earlier confidence that atomic energy would solve problems of the exhaustion of fossil fuels is one of the factors by which one can rationalize the small funding which has been given to cheapening the manufacturing of photovoltaic cells with efficiencies of 5 to 15%.<sup>4</sup>

A Hudson Institute energy policy paper concluded that "The main thrust of energy R&D in the post war period was and continues to be nuclear fission."<sup>5</sup> The article goes on to state that, "Possibly the most underfunded area of energy R&D is solar energy."<sup>6</sup> In fact, it was not until 1972 that a funded line for solar energy even appears on the charts of the Energy Research and Development Agency. In 1974 solar energy received \$12.2 million as compared to \$475.4 million for nuclear fission. The

discrepancy between the nuclear and solar R&D efforts appears even greater when it is considered in the light of the comparisons between the prospects for these two areas of energy R&D presented in the Paley Report on Natural Resources in 1952. The report, now almost forgotten, was an assessment by a government-sponsored commission of the prospects for different resources. Paley stated that:

Nuclear fuels, for various technical reasons, are unlikely ever to become more than about one-fifth of the (energy) load.<sup>7</sup>

At this time it does not appear that nuclear fission can be regarded as a contribution in any substantial degree to electric generation during at least the next ten or fifteen years, and the probability is that the atomic energy industry will remain a heavy net consumer of electricity.<sup>8</sup>

We must look to solar energy.<sup>9</sup>

Efforts made to date to harness solar energy economically are infinitesimal. It is time for aggressive research in the whole field of solar energy. ... alternative low cost sources of (solar) energy should be ready to pick up some of the (energy) load by about 1975.<sup>10</sup>

The recommendations of the Paley Report were not carried out in succeeding years. Even with the documentation of its inherent flaws and dangers, nuclear fission continues to be the U.S. government energy research and development priority.

Farrington Daniels (1964) described the state of solar research in the United States until 1964 as encompassing only several university scientists, including Telkes, Lof and Daniels and a few foundation research grants from The Cabot, Guggenheim and Rockefeller Funds. A conference every few years, the founding of a society of solar researchers in the mid 50's and the establishment

of a journal, Solar Energy, completed the picture. The level of activity barely constituted an Invisible College, a group of researchers in constant and productive interaction with each other. Although optimistically portrayed by Daniels, the solar research scene consisted of several fairly isolated individuals and small groups of researchers. Certainly there was no solar effort that could bear comparisons to the huge national research laboratories such as Livermore, Argonne and Brookhaven that were largely devoted to nuclear research.

The solar pioneers concentrated their efforts on improving heating and cooling devices. During this period, several solar houses were constructed for research purposes on university campuses such as MIT. Solar energy was found to be practical as the primary source of heating and cooling in these houses. Conventional heating and cooling systems were still required for supplemental energy. These prototype systems were costly, but economical units were expected to be feasible through mass production and "do it yourself" installation. A more serious limitation was that solar collection devices could only supply part of the energy requirements for a modern household. Electricity would still have to be produced from fossil or nuclear fuels. Nor could these simple solar technologies provide significant power for industry. Heating and cooling solar energy devices were best adapted to small-scale suburban and rural uses. Some solar proponents found this apparent limitation to be a positive advantage. Social theorists such as Ivan Illich (1974) and Murray Bookchin (1971), disturbed by the apparent inevitability

of trends to centralization and bureaucratization, found that solar technology mandated the development of small-scale decentralized communities. Illich and Bookchin argue that small-scale solar devices are the liberatory technology of a future society. Resource constraints and the elimination of environmental pollution make the small community a political and economic necessity.

This analysis has attracted a number of adherents. Its supporters provide much of the popular support for the development of solar energy. Yet this strategy has also given solar energy the reputation of an impractical technology for many who are not committed to a radically decentralized lifestyle.

Many persons support the goals of the environmental movement but are unwilling to commit themselves to a utopian lifestyle. This contradiction in the environmental movement is shown when on the one hand polls show widespread popular opposition to nuclear power plants but on the other hand there is voter support for nuclear power in referendums. This dilemma appears because most people are unwilling to give up the benefits of large-scale sources of power on which industrial society is based. Faced with an apparent choice between a highly industrialized society based on environmental degradation and a small-scale, low technology, environmentally pure society, most people choose the former.

To resolve this dilemma it is necessary, firstly, to separate, at least temporarily, the political struggle for a decentralized society from the environmental movement. Secondly,

it is necessary to develop a low cost source of pollution-free energy. If these two conditions can be met it is likely that the environmental movement would achieve overwhelming popular support in anti-nuclear referendums. A technology that fulfills this second condition, photovoltaic solar cells, has been close to the point of availability for over twenty years. However, political and economic forces have prevented solar cells from receiving sufficient research and development funding to attain cost effectiveness. It is our purpose here to explain how and why this suppression of technology has taken place.

The most promising solar development, the production of electricity from sunlight, was a byproduct of research on transistors. In 1954 an R&D team at Bell Laboratories announced the invention of photovoltaic devices that produced electricity with significant efficiency.

The photovoltaic effect existed largely as a scientific curiosity from its discovery by Becquerel in 1839 until 1958 when engineers at the Signal Corps Laboratory in Fort Monmouth used solar cells in a satellite as a power source. The only significant practical use found for the photovoltaic effect during the intervening years was as a photographic light meter. Bell engineers tried using solar cells to power rectifiers on telephone poles in the mid-1950's, but cells were found to be less economical than conventional sources of power. The lack of a large-scale source of demand led the Bell engineers to concentrate on small-scale uses for the high cost cells. By contrast, the existence of

a large-scale demand for transistors, even at high prices, from the armed forces for battlefield communications equipment resulted in the commitment of research and development funds.

Rapidly escalating demand for transistors to replace vacuum tubes and perform other electronic functions encouraged existing electronics firms (as well as several relatively new firms in the emerging semi-conductor industry) to develop simple methods for their production. The lowering of price that occurred as new techniques for transistor production were developed by several firms in competition with each other came to be known as the "learning curve." As the quantity of transistors produced was increased, the price dropped. (Silk, 1960) The introduction of improved production techniques corresponded in a reliable statistical relationship to the requirements for ever larger numbers of transistors.

The beginning of the learning curve for transistors was subsidized by the military. The Department of Defense built and equipped several pilot plants for private corporations to operate,<sup>11</sup> since the military was interested in using transistors in electronic gear in airplanes, computers and communications equipment. The Defense Department provided the capital and the initial high level of demand to set the learning curve process in motion for transistors. (Bello, 1953)

Solar cells have remained a limited product area of the semi-conductor industry. The use of cells in satellites provided the first and only demand for large number of cells. At the

height of NASA's interest in cells five companies were engaged in their production. However, demand remained at a sufficient level to support only two producers, Heliotek and Centralab. At the beginning of the 1970's these companies, research groups at a few other companies such as Motorola, RCA, the NASA Jet Propulsion Laboratories at Pasadena and a few NSF funded university researchers at Boston College and Harvard constituted most of the U.S. research and development effort in photovoltaics.

The price reductions that were achieved through research and development created additional uses for the transistor. A new industry developed as low cost transistors were used in radios, TVs and electronics equipment.

There was no source of demand for large numbers of solar cells at high prices to stimulate a similar cost reduction R&D effort for solar cells. This lack of demand is the explanation for the conclusion of a United States government scientific panel that:

Contrary to the experience with many other semiconductor devices, the cost of solar cells (about \$100,000 per kw generating capability) has remained unchanged during the past decade.<sup>12</sup>

The requirement of the space program for a reliable source of power led NASA to fund R&D on solar cells to produce large units. When NASA first began to use cells, units of only a few watts were available. By the early 1970's NASA sponsored R&D produced solar cell units measuring in the kilowatts. The NASA development work demonstrated that solar cells, joined together in arrays, had the potential to produce electricity

in large quantities (Boretz and Boring, 1972). The final step to make solar cells available for the production of electricity on a cost competitive basis with fossil and nuclear fuels would be the development of a low cost mass production method of manufacture.

During the late 1950's and early 60's several individual scientists proposed that solar cells could be developed as an economical source of electricity. Wolf (1959) proposed a staged program for the development of economical solar cells. The Ad Hoc Panel on Solar Cell Efficiency (1972) also proposed a strategy for the development of cells to make them cost competitive with other energy sources. Most of these proposals used learning theory and compared the potential development of solar cells to the actual development of transistors as economical devices. They expected the same pattern to be followed given the similarity between the two devices.

These recommendations were not followed by commitment of sufficient funds to achieve any significant results. As the Ad Hoc Panel stated:

The conversion efficiency of solar cells has increased slowly over the last ten years to a current level of about 11%. Of interest is the fact that virtually none of this increase occurred during the last five years. The panel believes that this plateau reflects a cessation of research funding rather than a fundamental limitation in cell efficiency.<sup>13</sup>

There was "no institutional source to support this research. The panel found that, "Commercial industrial incentive to improve the efficiency of solar cells has not developed to date."<sup>14</sup> The

relevant government agency, the Energy Research and Development Agency (ERDA), was committed to the development of atomic energy. ERDA itself largely consisted of the former Atomic Energy Commission with a few low funded divisions added on to deal with non-atomic energy technologies. The leadership of ERDA consisted primarily of former AEC officials. ERDA, despite its broader title and mandate, was still in effect the Atomic Energy Commission. Government research on solar energy remains under the overall control of individuals who are still committed to atomic energy. The new Department of Energy appears to follow the same line of bureaucratic descent and filiation. As one observer proposed, a serious government commitment to develop solar energy would require a new institutional beginning.

So far except for the support of the work done on solar cells, thermionics and thermoelectric devices for the space and defense agencies, the amount of money that has been allocated to solar research has been negligible. What we need, of course, is an Office of Solar Energy Research like the Office of Coal Research or, better yet, a Solar Energy Commission like the Atomic Energy Commission.<sup>15</sup>

Why we have had an AEC (Atomic Energy Commission) instead of an SEC (Solar Energy Commission) is the topic of the next section.

## II. The Nuclear Boom

Atomic energy has successively and simultaneously been a military project (i.e., atomic weapons development), a state bureaucracy (i.e., the Atomic Energy Commission) and a private

industry (i.e., the construction and operation of nuclear power plants by the electric utility and electric equipment corporations).

A military atomic energy industry was created during World War II. The atomic scientists provided the plans for the huge industrial facilities required to produce the components of the atomic bomb. The military provided the funding and the overall organizational structure to coordinate the research and development. Major corporations such as Union Carbide and Dupont were awarded the contracts to construct and operate the facilities. After the war Congress passed the Atomic Energy Act establishing an Atomic Energy Commission to operate the new industry. The Commission, consisting largely of scientists and business leaders, was civilian in background but its basic purpose was to continue and expand the production of atomic weapons. Two billion dollars were expended during the war and five billion in the earlier post war period to construct this atomic munitions industry.

A conceptual apparatus of legitimations was created in parallel with the physical construction of this industry in order to justify its existence. According to President Truman, atomic weapons were the basic guarantor of our national security. American proposals, such as the Baruch plan, to place nuclear weapons under the jurisdiction of the United Nations while maintaining ultimate American control were designed to maintain American military preeminence while expressing peaceful intentions. Failure of the Soviet Union to accept the facade of internationalization under American hegemony was publicized in the West as an expression of hostility. Despite public assurances that

atomic weapons insured American safety, their existence generated considerable anxiety about the possibilities of a world holocaust. To allay public concern, President Eisenhower was advised by scientists in the atomic energy program to set forth to the public the exact nature of atomic dangers. To this end a speech was prepared. The early drafts emphasized the destructive capacities of nuclear weapons. The President was uneasy with this approach, and so in a series of high level conferences a new orientation was worked out. According to Presidential advisor Robert-Donovan, "A way must be found, he felt, to raise the speech to a plane of sober understanding, combined with hope that the atom might serve man and not destroy him."<sup>16</sup>

The result was President Eisenhower's "Atoms for Peace" speech to the United Nations in 1953. It marked the beginning of large-scale government funding for the development of nuclear power plants to produce electricity. Although there were expectations by some scientists and journalists for the peacetime use of nuclear energy, virtually from the announcement of the use of the atomic bomb on Hiroshima and Nagasaki, few steps had been taken to this end until Eisenhower's speech. Gilpin (1962) argues that the political thrust for the creation of a nuclear industry came from the intention behind Eisenhower's speech. The desire not to scare the public with the announcement of the Soviet hydrogen bomb and to divert attention from America's lack of such a weapon at that time led Eisenhower's atomic energy advisor Lewis Strauss to propose to the President that he focus

the speech on non-weapons issues. In the speech Eisenhower offered to turn over America's then non-existent peacetime nuclear industry to the United Nations to spread its benefits to other countries. To make good on this speech civilian applications of atomic energy had to be developed.

The Atoms for Peace program was also part of the containment strategy to cordon off the Soviet Union from the rest of the world. Its goal was to draw non-aligned countries into the American sphere of influence. By showing these countries that their economic problems could be solved through the use of atomic energy technology only available through an association with the United States, it was expected that these countries could be drawn into the U.S. orbit. Although the initial U.S. proposals for peaceful use of atomic energy were presented along with a proposal for a new international agency as the implementing mechanism, in fact, most of the arrangements with participating countries took place through bilateral agreements with the U.S. As with previous American proposals such as the Baruch plan, it was not really expected that the Soviet Union would agree to participate.

The international agency aspect of the proposal was a propaganda ploy to make the proposal more palatable to the non-aligned countries. Once their interest was aroused, they could be expected to enter into negotiations with the U.S. when the international aspect of the proposal was not found to be feasible. The American plan was also proposed with the expectation that the U.S. could demonstrate its technological superiority and

thus by implication its political and moral superiority to the Soviet Union as a form of society.

This expectation was disabused when the Soviet Union released information about their own accomplishments in nuclear research. The production of electricity by atomic energy became a means of carrying on the Cold War between the U.S. and USSR through a scientific competition which soon extended into space and other areas. The expectations aroused in underdeveloped countries for the possibilities of atomic energy "...has tended to set back technological development in countries which attempted to realize the nuclear myth at any cost, giving atomic research priority over other important endeavors." (Nieburg, 1964) In succeeding years cost estimates continued to rise and the date at which nuclear power plants would become economical was pushed further into the future. By that time, many countries had committed large-scale resources to nuclear programs and these efforts had acquired their own momentum. Perhaps more important was the fact that whether or not they were economically feasible a civilian nuclear program provided the technical knowledge and industrial base for military applications. The military purpose of atomic energy continues to be the major reason for its development.

Civilian applications provided additional constituencies to support the development of atomic technology. The concern of several industrialists that this country's nuclear industry might prove to be a model for government controlled industry or socialism in the U.S. also led to a search for ways to transfer the nuclear

industry to private control. (Novick, 1976) In the early 1950's executives of the Monsanto and Dow Corporations and Detroit Edison initiated proposals for the creation of a nuclear power industry. The production of electricity for electric utilities was the means by which this transfer of the nuclear industry to private hands could be accomplished. The Duquesne Power Co. constructed a nuclear power plant to produce electricity at Shippingport, Pa. even though an economical process had not been achieved. According to Novick, "...the danger of government ownership overrode such considerations (i.e., an unprofitable technology); and a reluctant industry invested its stockholders' money in yet another struggle to stem the tide of socialism."<sup>17</sup>

Finally, the construction of a civilian nuclear industry lent credence to the assertion that the Atomic Energy Commission was a civilian agency even though the thrust of most of its work was the production of fissionable material for atomic weapons. The growth of a civilian nuclear industry served to legitimate the existence of the AEC on non-military grounds. The development of civilian applications also served to salve the conscience of scientists working on the nuclear programs, many of whom were concerned about the military consequences of their research.

With a civilian program in existence, many of these scientists could view their research in the traditional format of scientific research that can be applied to either war or peace uses with the decision left up to policy makers. Without a civilian nuclear industry these scientists would be more directly confronted with the military implications of their research. The use of nuclear

reactors to produce electricity allowed many atomic scientists to reduce the dissonance level that was created when colleagues raised questions about the ethical implications of their nuclear research.

The commitment of funds to development research on nuclear power plants was not made on the basis of judgment of the potential of nuclear reactors as a source of inexpensive power but rather as a legitimation for the continued development of atomic weapons. Public acceptance of atomic research was enhanced by shifting the research goal from maximum destructiveness. The development of nuclear power plants allowed the Atomic Energy Commission to be portrayed as an agency with largely civilian purposes; not the weapons arsenal to which most of its funds were directed.

### III. The Nuclear Industrial Complex and the Suppression of Solar Energy

The post World War II growth of a government-corporate nuclear complex provides a case study of the external forces that place some research questions on the agenda of large numbers of scientists and other questions on the agenda of small numbers of scientists. In the 1950's and 60's most physicists involved in energy research explored the use of nuclear energy. Few explored solar possibilities. This was the case even though the potential for solar electric technology was judged to be good and the potential for efficient application of nuclear technology to electricity production was ambiguous at best. The key difference between the two areas of research was that the commitment of government resources

to the development of the atomic bomb led to the creation of a large-scale nuclear industry as part of the military industrial complex.

The nuclear industrial complex was the last major segment of a bureaucratic coalition that joined the largest government agencies with major sectors of American industry. The organization of atomic energy followed the paradigm of other areas of the military industrial complex. A Planning Board was established by the federal government in 1942, before the construction of any large installations. Representatives from Standard Oil, Westinghouse, Union Carbide, M.W. Kellogg and the chemical engineering dean of MIT provided the linkage between the military and industry. The two major corporations chosen to develop Oak Ridge and Hanford, the centers of nuclear production, were Union Carbide and Dupont. "For all practical purposes these chemical trusts dominated the new industry which was in full operation as the war came to an end."<sup>18</sup>

Seymour Melman (1970) has demonstrated how the military industrial complex shaped the direction of American technological development in the post war years, emphasizing military applications at the expense of civilian uses. The development of nuclear energy and the non-development of solar energy was one aspect in the creation of the condition that Melman called "our Depleted Society." The concentration of technological development on military projects has resulted in backwardness in the civilian economy and in unmet social needs.

The linkages between the military and sectors of private industry were developed during two World Wars. In World War I the War Production Board, under the leadership of Bernard Baruch, provided the locus for major corporations to establish a relationship with the armed forces. Representatives to the Board from industry primarily consisted of persons from large corporations with an interest in contracts from the government. The Board essentially was a planning mechanism whereby the major corporations, with government sponsorship and legitimation, could decide the allocation of war contracts and the distribution of scarce material.

However, the conclusion of the war meant the dissolution of the Board. The maintenance of a small standing army in the post World War I period provided little economic incentive for corporate interest in the military. Nevertheless, the model of the War Production Board, as a corporate-controlled coordinating committee, was available for use when the economy had to be organized for military purposes during World War II. A new entity, the War Industries Production Board, was created to direct economic activity for the duration of the war.

After the second World War the linkages between the military and large corporations were not dissolved as they had been after World War I. This time peace was only a temporary interruption in the growth of the military. The linkages between the military and the large corporations were continued and institutionalized after World War II in the form of contracts for new weapons

systems. The contract state in which huge cost plus awards were made for the development of bomber and fighter planes, fire control systems, missile components, early warning systems to large corporations became a permanent part of the American economy. Heretofore industry had rapidly converted to wartime production and then reconverted to peacetime production. After World War II production of military goods took up significant percentages of the gross national product irrespective of whether or not the nation was at war. Through the establishment of a military industrial complex major corporations were enabled to make a significant share of their business depression-proof. Contracts negotiated with government agencies were not subject to the ups and downs of the economy or dependent upon shifting desires of consumers. By producing weapons systems to insure the national security, major corporations were also able to regain some of the prestige they had lost in the debacle of the 1930's depression. By allying themselves with the military, large corporations were able to improve their standing in three areas important to the maintenance of any large organization: stability, financial resources and legitimation.

The military implications of nuclear research and the possibilities it offered for the creation of an "ultimate" weapon that promised decisive power in the international arena to the nation that controlled it has been the basis for the massive funding of this research. Nuclear energy, even when intended for peacetime uses, may easily be utilized for military purposes. The

technicians, equipment and scientific knowledge involved in the use of nuclear energy to produce electricity may easily be applied to the construction of atomic weapons. Nuclear energy is inherently a military technology. While it may be directed toward peacetime uses under strict controls, it is difficult to insure that the controls will be adhered to and that a reactor that was constructed for the purposes of producing electric power will not be redirected to produce material for the construction of weapons.

Solar energy is a peaceful technology by its very nature. Whether used for heating and cooling or the production of electricity, it does not possess a destructive force. No military uses have been found for solar energy in the modern era. (Archimedes' apparatus for focusing the sun to set an enemy fleet afire, if true, is perhaps the only significant military use of the sun.) It is therefore difficult to conceive of the establishment of a military industrial complex based on solar energy.

If there is no military purpose for solar energy, what will be the impetus for its development? Certainly, the oil-energy corporations with their investments in nuclear energy will not be in the forefront. Their projections for solar energy is that it will become significant only in the next century. The advertisements placed in newspapers and magazines by Mobil Oil exemplify oil company policy on solar energy. Mobil cautions readers against accepting the claims of proponents of solar energy and states that practical applications of solar energy are far in the future.

Mobil's rhetoric in one ad said that, "Just about everyone concerned with energy these days -- ourselves included -- has high hopes for the eventual contribution solar energy will make. But some self-styled experts sound as if they've been out in the sun too long."<sup>19</sup> On the one hand, Mobil wishes to be counted among the proponents of solar energy, but on the other hand this corporation wishes to discourage any public belief that solar energy could be a practical technology in the near future.

The existing large corporations in the oil-energy industry are committed by previous investments to oil, coal and nuclear energy technologies for at least the next twenty to thirty years. The potential source of impetus for the development of solar energy lies in the confluence of the environmental and anti-nuclear social movements. What these movements require for their success is a viable alternative to existing energy technologies that is pollution free, environmentally safe and highly productive. Photovoltaic solar cells is an energy technology that is practicable and that meets these requirements. It will take the public education and political pressure that a large-scale social movement can provide to insure that financial and technical resources are directed to completing the final stages of research required to make solar cells cost competitive with other fuels. Only through a solar and environmental political movement directed toward this goal will scientific and technological ingenuity and sufficient financial resources be committed to converting the most "...abundant and reliable energy source, sunlight, into electricity, the most convenient and adaptable form of energy."<sup>20</sup>

Footnotes

- 1 A. F. Yoffee in Borisov.
- 2 Behrman (1976) p. 13.
- 3 Ibid.
- 4 Bockris (1975) p. 113.
- 5 Smernoff (1973).
- 6 Ibid.
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